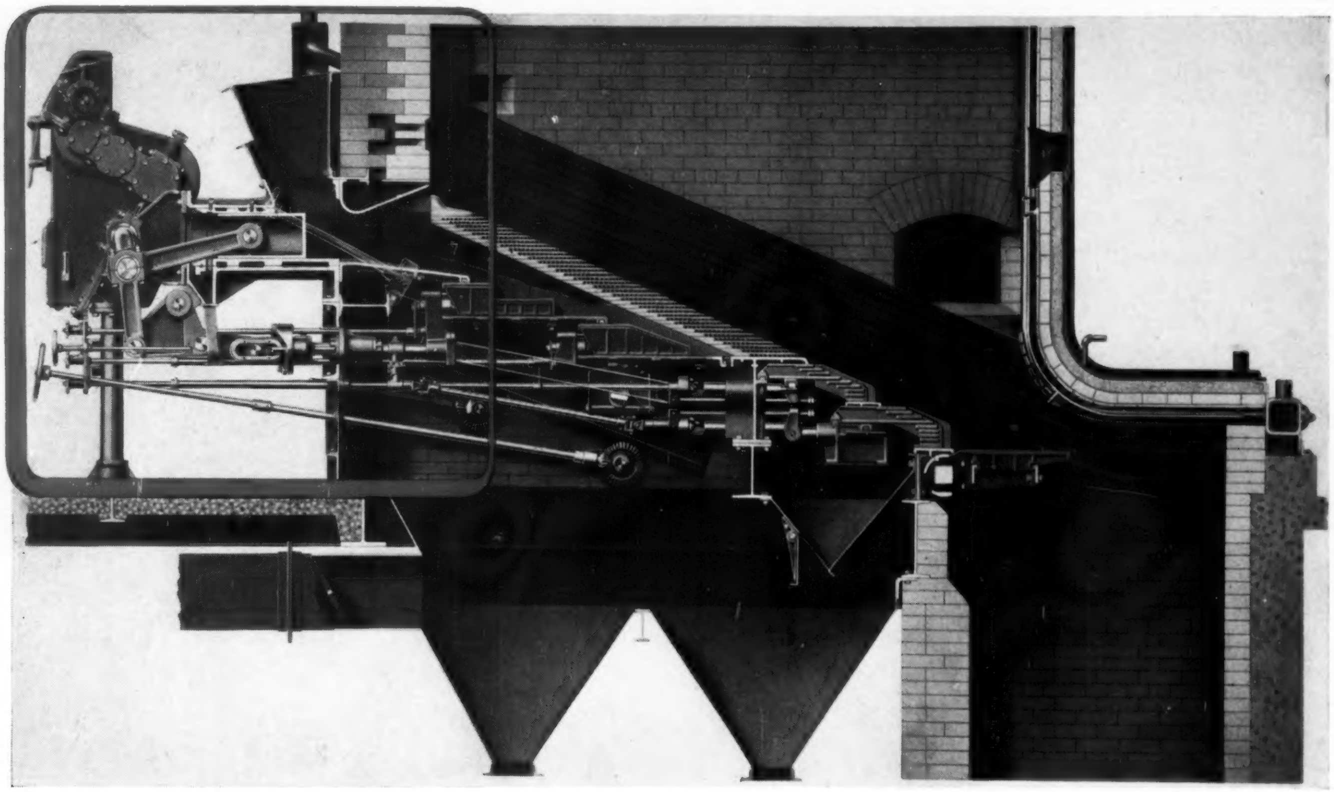
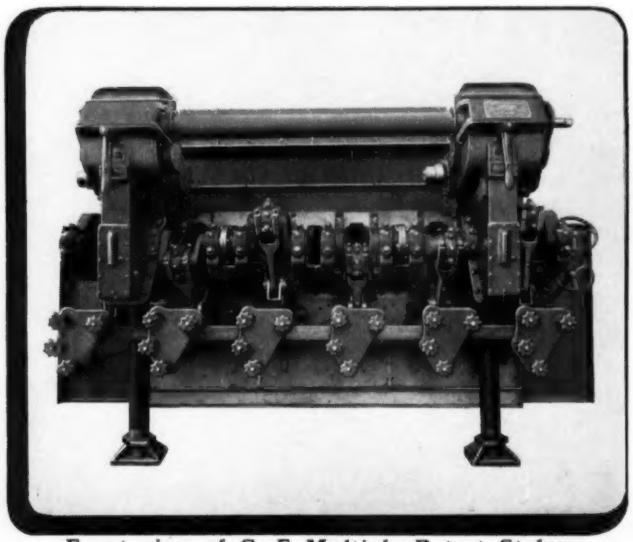
R S Hawley

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

July, 1942





Front view of C-E Multiple Retort Stoker showing convenient location of control wheels.

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FOURTEEN NUMBER ONE

CONTENTS

FOR JULY 1942

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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EDITORIAL

Power Meeting War Demands

Addressing the Edison Electric Institute on June 11, W. H. Harrison, Director of Production of the War Production Board, replied to the question as to whether the supply of power is meeting war demands. His answer was that "power is meeting war demands," and in no instance, to his knowledge, has production been delayed because of lack of power. This unequivocal assertion, although at variance with the earlier predictions of certain other government agencies, comes from one who is in a position to know the facts.

Mr. Harrison took occasion to commend the power industry for its ingenuity and effective integration of facilities in meeting the current situation, and further gave unstinted credit to the suppliers and manufacturers of equipment.

This sums up the situation to date but, lest it lead to complacency, he pointed out that heavier demands lie ahead, principally in the field of synthetic materials such as rubber and high octane gas. These plants call for vast quantities of steam and very large units, some comparable in size to those of central stations. Orders have already been placed for a considerable number of such units, under high priority rating, and it is assumed that their delivery will keep pace with the construction of these plants.

At the present stage of war production, however, materials are becoming the limiting factor, and this also applies to power equipment the manufacturers of which are faced with competitive demands of the vast naval and merchant shipbuilding programs. This is particularly acute as concerns turbine-generators and has already been reflected in the necessity for getting along with greatly reduced reserve capacity in many central stations and private plants.

It is gratifying to have the assurance from Mr. Harrison that thus far all essential war power demands have been met. As to the future, much may depend on the resourcefulness of the engineers concerned and possible curtailments in commercial and civilian use where necessary.

Reclaiming Scrap Materials

The Westinghouse Electric and Manufacturing Company reports that, as a result of having established a Reclamation and Salvage Department, it has saved approximately one hundred thousand tons of strategic war materials during the last twelve months. Without knowing the makeup of this scrap, it would be difficult to interpret it in terms of fighting units or their accessories thereby made available, but the number must be considerable. True, this is a large organization, handling numerous war contracts of great magnitude, but there are many other large companies and innumerable smaller ones similarly engaged. Some of these have already initiated salvage operations and if every one were to do likewise, the aggregate of materials reclaimed would go far toward relieving the present shortage in many of the critical materials.

Although manufacturing plants offer the most prolific source of such salvage, the twenty thousand power plants scattered throughout the country should be able to augment the available scrap by a large amount. An organized drive on the part of managements and operating groups toward achieving this purpose would be most timely. The salvage of scrap that has accumulated around many power plants is not only a patriotic duty, but the returns from its sale will be found to amount to several times the cost of collection.

Maintenance All-Important

At present, few plants are able to follow their customary scheduled outages of equipment for inspection and maintenance. Continuity of heavy loads and lack of reserve capacity, in many cases, make this difficult despite the more severe service demands to which the equipment is subjected. Fortunate, indeed, are those who can even approach some form of periodic outage for the purpose of checking up.

This situation calls for special alertness on the part of operating staffs in order to detect conditions which, if uncorrected, might lead to forced outage or failure. Where there is little opportunity to shut down for visual inspection, greater dependence must be placed upon audible indications and particularly upon instrument readings, such as will indicate the condition of equipment through comparison with normal readings. Never before has plant instrumentation held greater significance, aside from its value as an economic aid to operation.

Important as are inspection and the detection of incipient troubles, of equal necessity is adherence to operating procedure that will tend to reduce maintenance and minimize the chances of trouble occurring. Proper feedwater treatment, attention to furnace and combustion conditions, correct lubrication and adjustment of all moving parts, and good housekeeping throughout the plant are among the things that stave off excessive maintenance and forced outages.

The rôle of proper maintenance, as a vital factor in war production, has been recognized and stressed by a number of manufacturers, large and small, who have lately issued pamphlets giving detailed instructions as to the care of their equipment. Wherever possible, operators, regardless of their experience, should procure such instructions, give them careful study and put them into effect.

A number of semi-outdoor steam plants have been in operation for various periods up to 12 years and others will soon be placed in service. The economies to be effected with this type of construction, as compared with conventional designs, are discussed with particular emphasis on the present necessity for conserving steel and other critical materials.

By LOUIS ELLIOTT,
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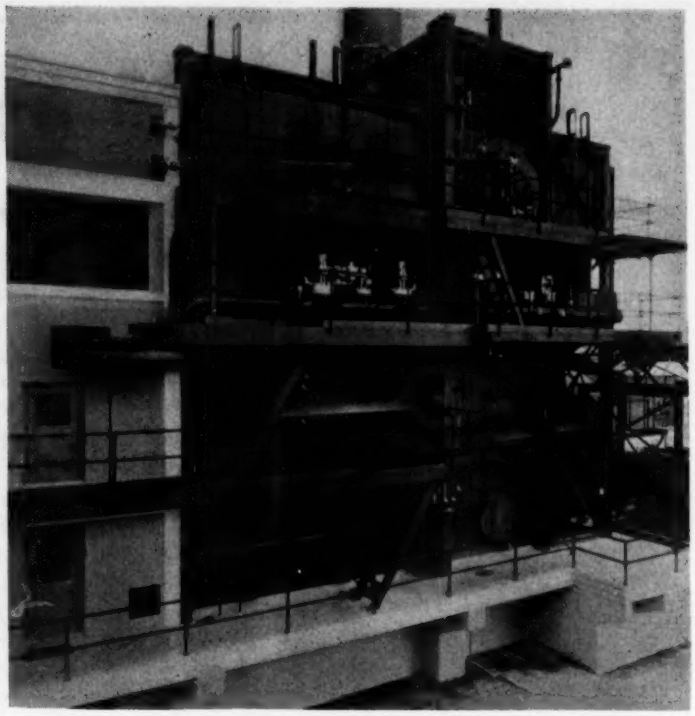


Fig. 1—View of typical semi-outdoor boiler installation

SEMI-OUTDOOR STEAM PLANTS Save Steel and Dollars

DURING recent years there has been developed, by a few steam-station designers, a semi-outdoor type of electric power plant. The use of this design permits substantial economies in investment and in materials required. Conservation of steel and other important materials is of particular importance at the present time.

By utilizing, for a moderate-size plant, a simplified semi-outdoor design instead of the older conventional fully housed type, savings in station building may be made approximately as follows: 75 per cent in cubic contents; 50 per cent in floor area; 50 per cent in structural and reinforcing steel combined; 75 per cent in structural steel alone (over 90 per cent if reinforced-concrete frame is used for the outdoor plant as compared with structural steel for the fully housed plant).

Fig. 2 shows in simple outline the comparison in plan and cross-section of the two types of plant under discussion—the semi-outdoor and the fully housed. In spite of the great reduction in size and cost of station building, for the compact design as compared with the earlier conventional type, which is still standard with most designers, there is no sacrifice in fuel economy. On the other hand, there is substantial saving in personnel required for operation and in expense for maintenance.

In a recent analysis of station designs, comparison is based on an installation consisting of one 25,000-kw turbine-generator and one 850-psi, 900-F natural-gas-fired steam generator, including economizer and air heater and with a separate chimney. The comparison would be little altered, for a plant with two or more similar units. Assuming a plant location on a suitable body of water, with condenser-injection temperatures ranging up to 80 F, and with the usual regenerative heat cycle, the year-round thermal economy for operation at high capacity factor would be approximately 12,500 Btu per net kilowatt-hour.

The building for the conventional fully housed plant adopted for this comparison is of a design such as was utilized 12 to 15 years ago by the engineering organization with which the writer is connected. The boiler house contains a single modern steam generating unit, served by forced- and induced-draft fans, with the latter discharging to a chimney on foundation at yard grade. The turbine room is of the usual ample dimensions, with full condenser basement and indoor crane. Auxiliary and electrical bays are also included.

For the semi-outdoor type, a station recently designed and under construction for a client is taken as basis of comparison. Its sectional elevation is shown in Fig. 3. The turbine-generator stands on an open deck and is protected by a weatherproof shelter, with a sectional removable roof over the steam end. A gantry-type crane runs on rails along the sides of the deck, with arrangements for handling turbine and auxiliary parts through a hatch provided in the deck. Space beneath the turbine, comprising a good-sized "basement" springing from grade, is utilized for condensing and other

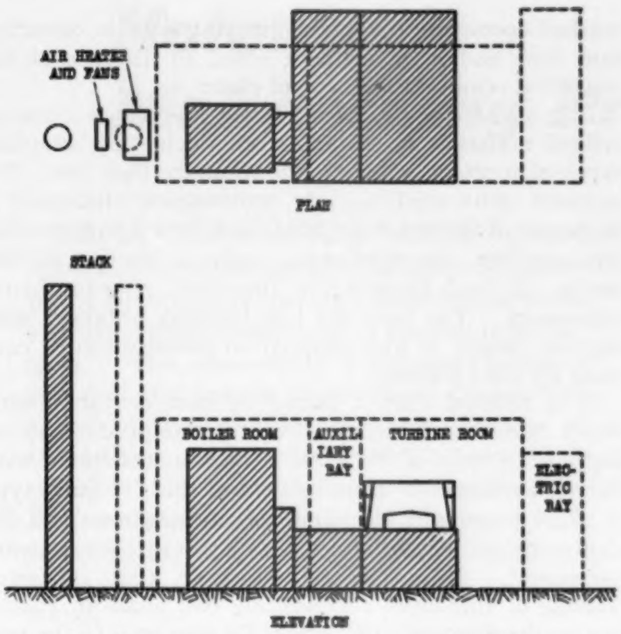


Fig. 2—Outline comparison of the two types of plant; cross-hatching represents semi-outdoor plant and dotted outline a conventional plant

auxiliaries and for a machine shop; a spur track may be brought into the basement, under the crane hatch, if desired.

The single steam generator is installed outdoors, with a concrete-slab roof supported by boiler columns, for weather protection; walkways and stairs at side of boiler are in the open. Air heater and draft fans are mounted on a foundation slab outdoors at ground level, alongside a separate chimney. The auxiliary bay between turbine and steam generator is used for mechanical and electrical equipment, for boiler and turbine controls, and for miscellaneous services such as office, laboratory, first-aid room, toilet facilities and lockers. The deaerating feedwater heater is placed outdoors on the roof of the auxiliary bay. This portion of building, together with turbine housing, will give full protection during normal operation to the station force, including men operating boiler, turbine-generator and auxiliary equipment.

Another important economy in design of steam-electric plants, and one that has been more and more effected during the past few years, is obtained by simplification in equipment and arrangement. Examples of this are utilization of one steam generator for a turbine, one circulator for a condenser, one induced- and one forced-draft fan for a steam generator, and in general the elimination of spares and duplicates. Some of these economies are being prescribed, today, by the War Production Board.

Electric utility companies, clients of the service organization by which the writer is employed, have encouraged and adopted simplified low-cost designs of steam plant during the past few years. In the earlier types, representing a transition from the more elaborate fully housed station, only the boiler unit is outdoors, with or without a canopy at top; the turbine-generator is housed in a turbine room and served by an indoor crane, or by an outdoor gantry operating through a hatch in the roof. Later designs utilize the semi-outdoor feature for the turbine as well as for the steam generating unit.

Many Semi-Outdoor Plants in Service

On client-company systems there are about a dozen of the semi-outdoor installations, aggregating over 300,000 kw in capacity, now in operation and under construction. The total saving in investment for these developments, as compared with expenditure for the more elaborate design of station, amounts to several millions of dollars. No close estimate of this saving is possible, however, as there is no definite design of older-type plant to serve as a basis of comparison.

These stations are installed in climates involving winter conditions varying from mild to temperate or severe. While there is in cold weather and under certain storm conditions some inconvenience or discomfort experienced in maintaining and operating this type of plant, as compared with the older fully housed designs, there is greater employee comfort during most of the year. For instance, the large hot boiler house is entirely done away with. The compact buildings lend themselves to the modern method of fan ventilation, elimi-

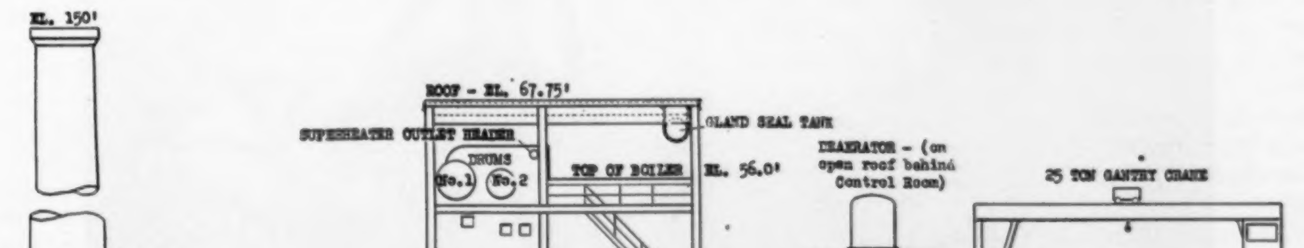


Fig. 3—Sectional elevation of recent semi-outdoor steam plant

nating ventilating sash and permitting filtering and positive control of air distribution. In general, it is believed that any disadvantages of these simpler low-cost installations are far outweighed by the investment saving, and by the economies and other advantages in operation and maintenance.

Seven of these semi-outdoor steam plants, on client-company systems, have been in operation for periods up to 12 years. Others, aggregating a greater capacity than the first seven, will be put into commission within the next year or so. The semi-outdoor plants have been successful in operation. Outdoor steam equipment has also been used for many years in steel mills, oil refineries, chemical works and other industrial plants. Hydro-electric plants have utilized semi-outdoor construction for thirty years. In fact, this type of construction has proved its economy and general soundness by several hundred plant-years of successful operation. Outdoor high-voltage substations, considered impracticable in 1910, are now the standard type.

Under normal financial and economic conditions—and more importantly during the present emergency—steam-plant designers should give careful consideration to the marked economies obtainable, in materials, in construction time and in investment costs, by the use of the simplified semi-outdoor type of plant.

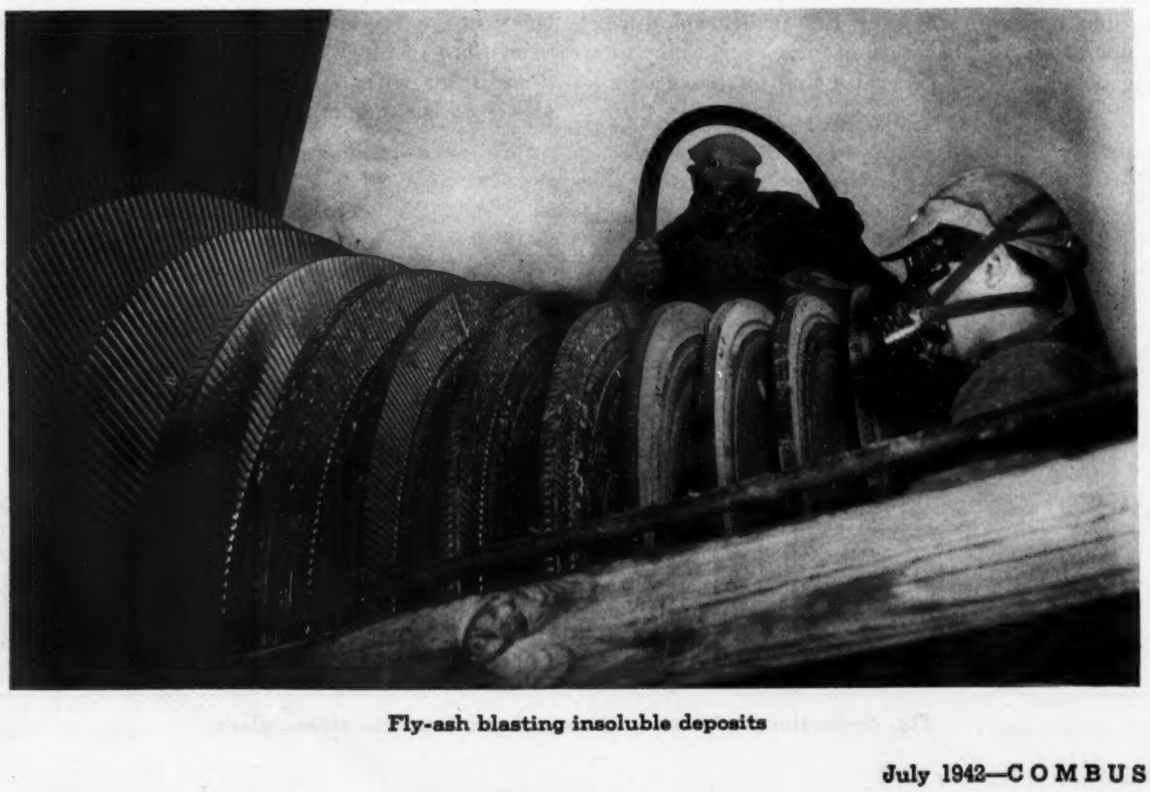
It is also of importance to avoid the use of scarce or critical materials in so far as practicable, by adopting types of construction that will minimize their use. For instance, reinforced-concrete construction eliminates a large part of the structural steel needed for a power house, and requires, for reinforcing, only a fraction of the weight of steel involved in the usual structural-steel framework. The compact low building obtained with outdoor design is well adapted to substitution of concrete for steel framing.

It is realized that a barrier of conservatism exists, which will retard the adoption of semi-outdoor steam stations, in spite of the great savings as compared with fully housed types. Development of this "radical" type of plant encounters the skepticism of engineers still designing monumental high-cost structures to house steam equipment. It is believed, however, that expensive housing of this kind, representing one phase in steam-station development, will gradually give way to the new economies.

Removing Insoluble Deposits From Turbine Rotor

The removal of soluble deposits on turbine blades can usually be accomplished by washing with wet steam at reduced load and speed, or during overhaul by subjecting the nozzles and buckets to a strong jet of water and compressed air. Insoluble deposits, such as silica, on the other hand, do not respond to washing and require that the turbine be taken out of service and opened up to permit mechanical removal. One of the most effective and widely used methods of removing such deposits is by means of a blast of fly ash. This, if properly applied, will not injure the turbine blades.

The accompanying photograph, reproduced through courtesy of the General Electric Company, shows this operation of fly-ash blasting silica deposits from the rotor of a large steam turbine during an overhaul period. Note the masks and goggles worn by the men operating the blast. These are quite necessary for their protection.



Fly-ash blasting insoluble deposits

Notes on Maintaining Proper Lubrication

Among the important factors toward insuring uninterrupted operation of power plant equipment, particularly under present exacting conditions, is proper lubrication. The following discusses broadly some of the points that should be kept in mind in the selection and application of lubricants, and particularly in making it possible for them to function properly. Acknowledgment is accorded the Technical Staff of Socony-Vacuum Oil Company for assistance in preparing these notes.

CORRECT lubrication of power plant equipment is always important from the standpoint of insuring minimum wear and saving in power consumption, but under present conditions when equipment is being subjected to unusually heavy loads for long continuous periods, often without opportunity for regular scheduled outages, lubrication assumes added importance. This applies not only to major equipment, but all along the line. Failure of an apparently minor auxiliary may mean forced outage of the unit served with consequent loss in production at a time when such loss may seriously affect the plant's contribution to the war effort.

In this connection, it is well to remember that the additional cost of the proper grade of lubricant, or of its replacement when indications point to the advisability of its renewal, is insignificant compared with that of the equipment served or the probable cost incident to a forced outage. This does not infer that one should resort to over-lubrication, which may incur other troubles, but rather the employment of the correct amount of the proper lubricant as determined by its suitability for the specific service conditions.

Because of various types of equipment employed in power generation and the numerous individual designs within those types, no attempt will be made to review in detail the lubrication of each. In this respect, recommendations of the equipment manufacturers and reputable oil companies are sufficiently comprehensive and should be followed. However, some general observations will be made, such as are applicable to a greater or lesser extent, to most types with a view to insuring maximum service.

General Considerations

Lubrication systems may be classified under two general headings, namely (*a*) *re-use* systems where the lubricant is used over and over again and (*b*) *all-loss* systems where the lubricant is used once and then lost. Circulation systems, ring oiling, bath oiling and grease-packed anti-friction bearings fall in the first category while hand oiling, drop-feed cups, waste-packed bearings and grease applied to plain bearings by means of screw-down cups or grease guns fall in the second classification.

In re-use systems, the lubricant is continually agitated in the presence of air and is thus exposed continually to its oxidizing influence. At high temperatures this oxidizing influence is greatly increased. Thus, one of the principal characteristics that an oil suitable for re-use systems should possess is high chemical stability. This enables the oil to resist oxidation and the formation of deposits and sludge, permitting long periods of useful service. This characteristic is also required of grease in re-use systems, but, in addition, it must resist separation of the oil and soap constituents even when subjected to severe churning. High chemical stability is an unnecessary characteristic for oil that is to be used in all-loss systems.

Oil applied by all-loss methods is usually fed sparingly and a full fluid oil wedge exists for only short intervals after each application of oil. As a result, oil films approach microscopic thickness, a condition often called "boundary lubrication." Under these conditions high film strength and adhesiveness are necessary characteristics to resist rupture, metal-to-metal contact and excessive wear.

In any system of lubrication, the lubricant must be sufficiently fluid to distribute in the bearing, but not so fluid as to cause excessive leakage. It must be sufficiently heavy at the operating temperatures to resist rupture under the loads imposed upon it. Too heavy or too light a lubricant, or the use of too much oil or grease in high-speed anti-friction bearings is likely to lead to high bearing temperatures.

The wear of plain bearings and the fluidity of the lubricant are closely allied in influencing leakage. A relatively light bodied oil or soft grease may be used in newly fitted bearings without much leakage from the ends, but when wear increases the clearances, a greater opportunity is afforded for leakage of the light oil or grease. The resulting increase in the consumption of the lubricant may be somewhat offset by the use of a heavier bodied oil or a stiffer grease, but at the expense of power consumption. Moreover, if too heavy an oil is used it may not distribute properly in the bearing and will thus cause excessive wear. Of course, the proper procedure is to correct the excessive clearance and provide correct lubrication to minimize recurrence of wear. Aside from the use of unsuitable lubricants, excessive wear may be brought about by abrasive dirt in the system, by an interrupted or inadequate supply of oil or grease, or by improper distribution of the lubricant over the surfaces.

To minimize contamination with dust or dirt, the covers of oil wells should be kept tightly closed and before opening they should be cleaned to prevent dirt

from falling into the system. Also grease-gun fittings and cups should be wiped clean before applying grease. Bearing seals and dust seals should be maintained in good condition and, if worn or injured, should be replaced at the first opportunity.

Motors

Because of their wide and varied applications, not only throughout most plants, but also for driving auxiliaries, motors will be considered first.

The lubricants selected for motors must be of sufficient film strength and body to form and maintain the film, but light enough to avoid unnecessary fluid friction in the comparatively small clearances in plain bearings. In ball and roller bearings, the lubricant must provide a protective film to prevent corrosion and deterioration of the highly polished surfaces.

Bearings of motors, especially those subject to frequent intermittent operation, require that a starting film of lubricant be present to minimize wear and starting torque. Although light oil is ideal for continuous operation, such an oil tends to run from and be squeezed out of the relatively small clearance during idleness, leaving the surfaces of the shaft and bearing dry and in contact. Hence, wiping and slight wear will be produced at starting until a separating film has been built up. Heavier oil, having greater adhesive properties, will maintain its film for a longer time and thus reduce wear and torque at starting. In medium size and large motors, this is important; but very small motors, because of the small bearing clearances, require a light oil.

However, the location of the motor is a factor. Because viscosity changes with temperature, a heavier machine oil must be used if the operating temperature is high, whereas the opposite applies to low temperature operation.

Lack of lubrication or grit will produce wear and this will permit the rotor to drop from its concentric position and thus disturb the magnetic balance. In fact, the wear may become so pronounced as to cause the rotor to rub on the stator and damage the windings.

Over-lubrication, on the other hand, may be equally harmful as leakage of excess oil or grease from the ends of bearings will be drawn into the motor and deposit on the windings, commutator, slip-rings and brushes. Dust will adhere to these surfaces and sparking, breakdown of insulation or excessive heating due to impaired ventilation may result. Wherever possible, always fill ring-oiled bearings while the motor is idle, thus assuring the maintenance of a proper oil level.

It is good practice to inspect oil rings periodically to be sure they are turning with the shaft; drain the oil reservoir occasionally, clean with a light oil or carbon-tetrachloride and dry thoroughly before refilling. This is especially important in dusty or damp locations.

Stokers

These, according to the type and local conditions, may be driven by steam pistons, steam engines, steam turbines or electric motors—direct or through variable-speed transmission or hydraulic drive. The steam piston and the steam engine employ cylinder oil for internal lubrication and engine oil or cup grease for the external parts. Motors call for a light or medium turbine or engine oil and the gear lubrication is dictated by the type of drive. Worm gears generally employ a heavy steam cylinder oil, such as 600W. Where the gear case is of the open type, a heavier oil is required to prevent splash and consequent leakage. A medium heavy engine oil is satisfactory for the transmission gear case on a traveling grate stoker. Shaft bearings of the sleeve type use either oil or grease and those of the roller or ball-bearing type employ either a good grade of machine oil or anti-friction grease. Grease cups lubricate rocker arms and a medium body oil that will distribute between the rollers and pins is generally employed for chain drives.

Because certain parts of stokers operate in a zone subject to relatively high temperature, the melting point of the grease is important. Also, because dust and ashes are ever present, it is well to drain, flush out and refill gear cases about every three months, depending on conditions. Make certain that all dust and grit are removed from the gear teeth, gear cases and other moving parts. However, during the initial period of service it is usual to renew the oil after a month's operation and thereafter occasional inspections are advisable. One should make sure that all joints of the gear box are tight in order to prevent leakage.

Pulverizers

Because of the several types and numerous designs of mills only general remarks on their lubrication will be included. Heavy loads, high temperatures and impact as encountered in pulverizers impose a heavy duty on the lubricants, and the presence of dust requires special precautions against its entrance into the bearings.

To maintain a continuous oil wedge and obtain the advantages of a full fluid film, leakage of oil from the ends of plain bearings must not be greater than the rate at which oil is drawn into the pressure area. In low-speed mills replacement of the oil film is slow, hence a relatively heavy body oil is required to minimize leakage; but with high speeds the oil is drawn in more rapidly and a lighter oil can be used which will distribute quickly and reduce fluid friction. However, where operating temperatures are high, a heavier bodied oil must be used to counteract the thinning effect of heat and to assure maintenance of the necessary separating film.

Many mills employ anti-friction bearings, and one of the chief aims in lubricating such bearings is to protect the surfaces and guard against pitting or corrosion; also, to prevent excessive heating by minimizing slippage. Fine dust of a more or less abrasive nature tends to work into every crevice, and grease, while possessing certain sealing qualities, should not be depended upon to exclude all grit.

Where grease is used in such bearings operating at relatively high temperature, it must not become fluid at that temperature and must resist oxidation. The balls, or rollers, subject the grease to severe churning which tends to separate the oil and soap content, hence it is important that the grease be of such quality as to resist separation.

The driving gears, vertical-shaft and thrust bearings of some mills are lubricated by a circulatory oiling system and, if dust and grit are excluded, the same oil may be continued in use for a long time, provided it passes the high chemical stability necessary to resist deterioration due to oxidation. However, it is important that its condition be noted periodically.

Steam Engines

Excessive wear of cylinder walls and piston rings, while sometimes the result of poor alignment, sharp-edged rings or unsuitable metal, is frequently traceable to faulty cylinder lubrication. This may be due to inadequate feed, poor distribution or improper oil for the operating conditions. However, the mechanical condition of the piston rings plays an important part in cylinder lubrication, for if the rings are worn, the continuous blow-by will make it difficult to maintain the necessary oil film.

Steam cylinder oil must possess a heavy body and maximum chemical stability to avoid deterioration under the temperature conditions encountered. If the viscosity is too low, excessive feed will be required, and this, in turn, tends to form deposits. With wet steam, or where cylinder condensation occurs, it must have strongly adhering qualities to resist being washed off the surfaces. When an engine operates at partial load with early cut-off, cylinder condensation is more pronounced. With a correctly compounded oil, adequate lubrication can be maintained with decreased rates of feed, thus reducing the amount of oil carried out of the engine with the exhaust. As a result, heat-transfer and boiler surfaces can more easily be maintained free from oil and consumption of lubricating oil is minimized. A straight mineral oil is usually preferred for highly superheated steam under such conditions.

Groaning during steady operation, or while under heavy load, is usually the result of poor lubrication, although other causes may be responsible. If the groaning occurs when starting the engine after a shutdown, the cause may be rusted surfaces or an impaired oil film. The remedy is to feed oil liberally while shutting down so that a heavy oil film will remain during the idle period. Where this has not been done, additional oil should be fed just prior to starting up.

Deposits in the counterbore of the cylinder or behind piston rings of engines operating at low or moderate temperatures are usually due to impurities in the steam, although use of a poor quality lubricant may contribute. At high operating temperatures, of 500 F and above, deposits in the cylinder or on the stems of poppet valves are usually indicative of the use of an improper quality of oil.

Chatter of valves is usually a matter of lubrication although steam temperatures higher than those for which the valves were designed may cause warping and, in turn, produce chatter. In that case, reconditioning of the valves and seats is necessary. Also, gum or carbon deposits from over-lubrication or use of an oil that does not resist carbonization on valve stems may cause sluggish cutoff and thus affect regulation.

While the exterior lubrication of steam engines usually does not present a problem, emulsions in oil reservoirs may interfere with the oil circulation. Also, restricted oil lines, improper grooving within bearings, insufficient feed or use of unsuitable oil may be conducive to hot bearings and excessive wear. Knocks in bearings are generally due to excessive clearances which should be reduced to the proper amount at the first opportunity. A knock can only get worse if not corrected and may ultimately damage the babbitt. Of course, there are other mechanical causes for hot bearings and knocks which should be investigated whenever these conditions occur and their causes rectified.

Steam Turbines

From the standpoint of value of the unit served, lubrication of turbine-generators ranks first in importance. Much has been written on the subject, hence the following will deal only with general operating precautions.

Before starting a turbine, either initially or after a long period of idleness, it is important to make certain that the oiling system is scrupulously clean. To do so, first inspect the water and oiling systems, removing all foreign matter and dirt by blowing out the piping, and tighten all loose oil or water joints. If possible, circulate a small quantity of service oil with the auxiliary oil pump for at least eight hours to flush the system. During this operation the oil piping should be pounded to loosen and remove any pipe scale or rust. After flushing, drain the oil and clean the system as thoroughly as possible. The drained oil should be purified and may then be used for makeup. Then fill the system until the reservoir gage registers "full," being sure to remove all dirt from the outside of the barrel. All miscellaneous bearings of the governor gear and steam admission valve should be inspected and lubricated thoroughly.

In starting, the manufacturer's instructions should be followed, but it is also important to see that the main oil pump functions as the turbine picks up speed and that the correct pressure is maintained at all points. When the temperature of the oil leaving the bearings reaches 110–120 F, start the circulating water through the cooler, and permit the oil to rise quickly to operating temperature (130–140 F), and decrease any tendency toward foaming. After the turbine has been brought up to speed, the oil and water temperatures should be noted at regular intervals and any sudden change should be investigated.

After the machine has operated for about 300 hr, unless it has a continuous bypass filtration system, it is advisable to drain the oil from the system, filter it, and use it for makeup. This precaution will insure the removal of any foreign matter that has become dislodged during this period of operation. Before recharging, clean the reservoir, cooler and bearing pedestals.

When a turbine is down for a periodic inspection, the frequency of which varies widely with different plants and according to the demands of the service, it is well to inspect carefully and thoroughly clean the oiling system, particularly disassembling the oil cooler, during this operation. Also thoroughly clean the hydraulic governor system and inspect the pumps to be sure they will function properly.

If the shaft packing glands and the oil-retaining rings are not in good condition, steam and water may be carried along the shaft and into the pedestals and contaminate the lubricating oil. Water should not be turned into

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NOTE: There have been cases of rusting in oil reservoirs and lubricated turbine parts during the past few years. Rusting may be due to water entrance in the oil or to conditions during erection or periods of shutdown. There has been a feeling on the part of some manufacturers that highly refined oil does not preferentially wet the metal surfaces and thus does not provide adequate protection against rusting. This has formed the subject of much study and research by the oil companies and inhibitors have been produced to counteract this condition. In many cases the addition of a small amount of used oil has been found effective in establishing an inhibiting effect until these qualities had been built up in the new oil.—EDITOR

the water seals until the turbine is up to half-speed as the centrifugal force of the impeller is not sufficient to form an effective seal below this speed. For the same reason, water should be shut off from the seals as soon as the steam has been cut off. Accumulations of water in the oil form emulsions which may become permanent if the oil is in poor condition.

Excessive losses from the oiling system are traceable to leaks which may or may not be visible. Therefore, felt washers and metal oil guards should be inspected periodically, and, if worn, they should be replaced. Leakage may be due to excessive pressure in the supply line or to too high a level in the pedestals of ring-oiled bearings.

It is most important that a systematic check be kept on the condition of the oil by taking samples at regular intervals from points where the oil is in circulation. As long as there is no marked change in the appearance of the oil, and no water or sediment is present, the serviceability of the oil can be assumed. But a change in appearance or the presence of water, or small amounts of sediment, does not necessarily mean that the oil should be removed from service. The suitability of an oil for further use can be determined only after a laboratory analysis and the interpretation of the analysis by a lubrication engineer familiar with the oil in question. Full operating records should be maintained as to the supply of oil, the condition of the oil and of the system, and all inspections.

Fans and Pumps

In general, the remarks concerning the lubrication of motors apply to fans and centrifugal pumps. The latter, according to the type of service and operating conditions, are provided with ring-oiled sleeve bearings, gravity or circulation oiling for the thrust bearings, or ball bearings either oil or grease lubricated. For steam-driven reciprocating pumps, the remarks concerning steam engines apply.

Air Compressors

Air compressors are either of the reciprocating or centrifugal types, driven by steam engines or motors. In so far as the driving unit is concerned, what has been previously said will apply. The centrifugal compressor requires no internal lubricating and its shaft bearings employ ring oiling, circulation oiling or forced lubrication. As in the case of motors, where oil-ring lubrication is provided, the reservoirs should be ample to permit impurities to settle and they should be observed and cleaned out whenever necessary.

In the case of reciprocating compressors, it is the internal lubrication that requires special consideration. Only a small amount of oil is required to be fed to the cylinders—just enough for effective sealing and lubrication of the piston—as an excess of oil is likely to lead to carbonized deposits on the valves and to conditions that create an explosion hazard. The oil should not contain any constituents which might tend to give off highly explosive vapors even at temperatures well above ordinary operating conditions. Its viscosity at the operating temperature is important, as too thin an oil will not effectively seal the piston and is readily carried into the intercooler or air receiver. Too heavy an oil is likely to cause the formation of deposits, also to increase the friction and thus decrease the power going into useful production.

Of course, attention should be given the crank-case lubrication to see that it is functioning properly and that the oil is carried to the correct level. Also, it is necessary to make certain that the oil wiper surrounding the piston rod is keeping oil out of the cylinder. Cleanliness is most desirable around all power plant equipment but it has particular significance around an air compressor because of the potential hazards involved.

There are many other pieces of equipment within the power plant that require lubrication, including control equipment whose proper functioning is most important. Some present more special problems than others, in which cases the recommendations of the lubrication engineer should be scrupulously followed. It should ever be kept in mind that correct lubrication not only means saving in wear and in friction losses, but may avoid costly shutdowns.

Turbine Shaft Repaired in Seven Hours by Metalizing

A middle west power company was recently forced to shut down its 6000-kw turbine-generator because of a worn shaft. Two areas of wear were noticed in the water-seal section of the 18-ton forged-steel shaft. One worn area was approximately three inches wide at the 11-in. diameter section of the shaft; the other had occurred where the diameter was $10^1/_2$ in. and had worn an area about 2 in. wide.

In selecting the method of repair, it was decided that metallizing with No. 2 eleven-gage stainless steel wire was the best answer to the problem.

The worn sections were first undercut about three-sixteenths of an inch, and then grooved and knurled. A rig was hooked up on the bed of the turbine to accommodate the cutting and knurling, and to hold the MOGUL gun during the spraying operation. An electric motor with a reduction pulley arrangement was rigged to the turbine end of the shaft and revolved the shaft at a speed of about five revolutions a minute during both the preparation and the spraying operations. An auxiliary air jet was played upon the opposite side of the shaft to facilitate cooling during the spraying. Following the spraying, the shaft was ground to size and re-assembled in the generator. Propane gas was used, and the entire job was completed with 40 lb of wire, and in only seven hours.

The cost for salvaging the shaft was a fraction of the cost for a new replacement, and in these times, it is doubtful that a new shaft could have been obtained within a reasonable period at any price.

It was interesting to note that while the turbine was down, the part of the shaft which had been similarly metallized three years ago was examined and no appreciable wear could be detected.

Pointers on the Storage of Coal

By J. F. BARKLEY

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Bureau of Mines, U. S. Department of the Interior

Under impetus of the "Buy Coal Now" campaign sponsored by the Government, the stocks of bituminous coal held by consumers and dealers increased 4,611,000 tons during April. Many small industrial plants lack the experience of storing coal in large quantities, and this article, based on an address given before the National Association of Power Engineers and recently issued as an information circular by the U. S. Bureau of Mines, provides an authoritative answer to questions concerning the safe storage of coal which may arise in the minds of coal users who are increasing reserves in compliance with the Government's request.

DURING the present war emergency, under the urge of the Federal Government to store coal, the following questions are arising in the minds of coal users:

Will the coal lose any of its heating value in storage?
Will it slack and give a smaller-size coal?
Will its burning characteristics change in any way?
Will it catch fire from spontaneous combustion?
What precautions should be taken when storing coal?

Loss of Heating Value

In regard to the loss of heating value of coal in storage, tests made by the Bureau of Mines show that the loss commonly has been overestimated. Various types of storage tests were made on New River, Pocahontas, Pittsburgh Gas, and Sheridan Wyoming coals. The following is quoted from Bureau of Mines Bulletin 136, "Deterioration in the Heating Value of Coal During Storage," by H. C. Porter and F. K. Ovitz:

"Except for the subbituminous Wyoming coal, no loss in heating value was observed in outdoor weathering greater than 1.2 per cent in the first year or 2.1 per cent in 2 years. The Wyoming coal suffered somewhat more loss, 2 to 3 per cent in the first year, and as much as 5.5 per cent in 3 years."

Slacking of Coal

The extent of slacking of coal in storage depends principally on the rank of the coal. The lower-rank coals, such as lignite, subbituminous coals, and high-volatile, high-inherent-moisture bituminous coals, slack from weathering much more readily than the higher-rank coals. The slacking, under good storage conditions, ordinarily extends only a short distance into the coal from its exposed surface. Very little difficulty, if any, from slacking should be experienced with the higher-ranking eastern coals. The Bureau of Mines has developed a laboratory test to indicate the tendency of a coal to slack.[1]

Changes in Burning Characteristics

Some changes in burning characteristics may occur in certain coals in storage. It is of importance primarily for slack-size coals. For example, the caking tendencies of the coal may decrease appreciably. Whether or not the decrease in caking or coking tendencies affects the efficiency of the fuel-burning equipment depends upon its type. For example, such coal would not burn nearly so satisfactorily on a hand-fired down-draft furnace; after being stored for many months it would not stay on the upper grates as well. Storage might improve the coal for use on domestic underfeed stokers or chain-grate stokers; for spreader stokers it would make little difference; for large underfeed stokers the efficiency might be affected. Sometimes coal, particularly low-volatile slack after long storage, acts "dead" as described by a fireman; that is, it does not seem to ignite so readily at the lower temperatures. This tendency is noticeable chiefly in hand-firing where furnace temperatures are not particularly high. There also may be slight changes in the mineral matter of the coal, which oxidizes to some extent. Such changes need not ordinarily be given much consideration.

Spontaneous Heating

Whether or not a coal will heat in storage from spontaneous combustion depends on many factors. Owing to the complexity of these factors, exactly when and how much the coal will heat cannot always be judged for every storage condition. It is not difficult to store coal provided these factors are evaluated correctly and the means are at hand for carrying out the proper methods needed for each case.

Oxidation of the coal substance itself is the main cause of spontaneous combustion; some of the organic constituents may contribute more to the heating than others, but it has not been shown that any one constituent exerts a preponderant influence to the exclusion of the rest.

The process of spontaneous heating is operative at room temperatures as soon as freshly broken coal is exposed to the air. It begins with the physical absorption of oxygen and is continued by the formation of a solid chemical compound of coal and oxygen, which is gradually decomposed as the temperature rises. The coal increases in weight by the amount of oxygen retained. There follows the beaking up of the solid com-

[1] Fieldner, A. C., Selvig, W. A., and Frederic, W. H., "Accelerated Laboratory Test of Determination of Slacking Characteristics of Coal," Bureau of Mines Report of Investigations 3055, 1930.

pound of coal and oxygen and the formation of the final oxidation products—carbon dioxide, carbon monoxide and water. This process generates heat.

With the Appalachian coals, oxidation begins to be appreciable at about 85 F and increases in intensity as the temperature rises. With lower-rank coals the beginning temperature is lower. The rate of heating increases with the temperature; that is, no coal has as an inherent property a critical temperature at which there is a sharp transition from relatively slow to rapid heating.

Pyrites when finely divided can increase the tendency of a coal to heat spontaneously. Although it has been shown that coals containing virtually no pyrite have fired spontaneously, it has also been shown that fine pyrite does increase the rate of oxidation.

Opinions differ as to what effect moisture in coal has on spontaneous heating. Probably the effect of moisture is determined by the conditions of storage.

Chemical factors other than those touched upon have little or no influence on the spontaneous heating of coal.

An important factor is the total surface area of the coal exposed to the air; the greater the surface the more

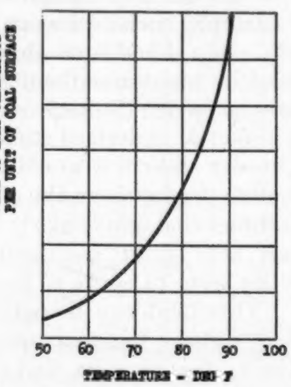

Fig. 1—Generation of heat in coal pile at increasing temperature

chance of union with oxygen. The accompanying table shows the variation of surface area with size. For a ton of coal in the form of a solid cube, there is about 48 sq ft of surface; as the cube is broken down to smaller sizes, say to slack coal, there may be 8000 or 10,000 sq ft. Experience indicates that good size egg or lump bituminous coal when stored ordinarily gives no trouble from spontaneous heating, mainly because there is not enough surface area.

Variation of Surface Area of Ton of Coal With Coal Size (coal considered to be in the form of cubes or spheres of the size designated)

Size	Sq Ft per Ton	Size	Sq Ft per Ton
2.83-ft cube	48	4-mesh	8,727
6-in. lump	272	8-mesh	17,416
3-in. nut	544	16-mesh	34,796
1 1/2-in.	1088	30-mesh	70,341
3/4-in.	2176	50-mesh	139,479
3/8-in.	4352	100-mesh	276,595

Another factor is the temperature of the coal; chemical action increases in intensity as the temperature rises. The reaction between coal and air doubles for about each 10 degrees F. If the temperature of the coal is 60 F and it is raised to 80 or 90 F, the rate at which the oxygen of the air unites with the coal increases four to eight times. Fig. 1[2] illustrates this action.

[2] Figures taken from Hood, O. P., "Spontaneous Combustion of Coal," Bureau of Mines Inf. Circ. 7074, 1939.

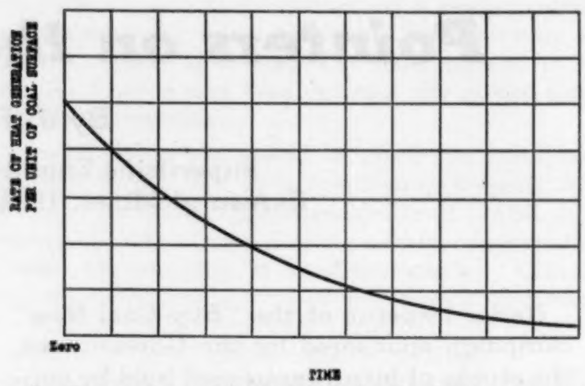

Fig. 2—Generation of heat in coal pile during increasing periods of time. Heat removed

If the heat developed spontaneously is removed as rapidly as it develops, the coal temperature will not rise. Fig. 2 shows how the rate of heating decreases when heat is removed. In a pile of coal where the heat is not removed, however, the rate may increase very rapidly; it is self-aggravating. Fig. 3 illustrates the action. The problem of storage of coal is to remove the heat at least as rapidly as it is generated by oxygen. A pile of coal, therefore, might do anything from actually cooling to very rapidly catching fire, depending on heat removed.

Air moving through a pile of coal supplies oxygen for burning and also carries away heat. It may cause increased heating or increased cooling, depending upon the amount. When coal is piled by letting it drop the larger lumps fall to the outside (see Fig. 4). Such a pile creates an ideal condition for spontaneous heating. If one spot heats, it will gradually heat the whole pile. There is always the chance that some spot will receive exactly the right ventilation so that the correct amount of oxygen is brought in and yet not enough heat is carried away, as illustrated in Fig. 5. There is much air movement on the outside edges, yet in the center the air can hardly penetrate. There is no ventilation at some spots and much at others. Naturally, somewhere in the pile will be a spot where there is just the right ventilation to produce a "hot" spot. Fig. 6 shows such a spot at *A*.

The time element is also a factor. A pile of coal might stand for three or four weeks without trouble, as it has not had time to heat up; but later it might take fire.

Spontaneous heating can be prevented or lessened by:

1. Storing Coal Under Water.—Water prevents the access of air. It does not appreciably harm the coal except to make it very wet. This is often quite un-

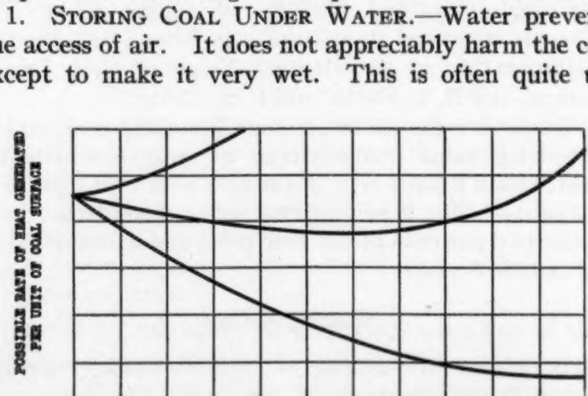

Fig. 3—Generation of heat in coal pile during increasing periods of time. Heat not removed

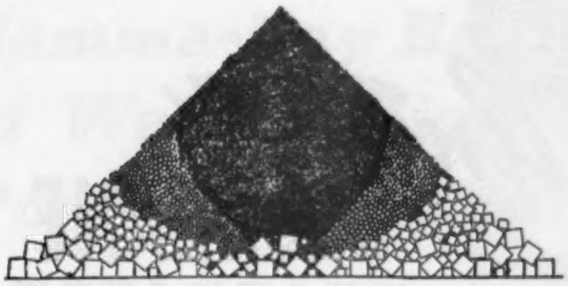

Fig. 4—Segregation of different sizes of coal in a conical pile

desirable. If the very fine sizes are removed previous to under-water storage, the water will drain much better from the coal when it is taken from storage. Usually a cheaper and more satisfactory way of storing can be devised for most coals.

2. Compressing the Pile in Layers as With a Road Roller or Tractor Bulldozer to Prevent Access of Air.—If the pile is packed tightly, little air can reach the coal. This method is used considerably, particularly by the larger coal users.

3. Storing Large-Size Coal.—This is practicable for the domestic consumer. Coals that give trouble when stored outdoors in ordinary piles in the slack sizes frequently give no trouble if the fines, say below 10-mesh or even smaller, are removed before storage.

4. Preventing Any Segregation of Sizes in the Pile.—It is usually best to pile in layers. This prevents such a wide variation in the air movement through the coal. Many of the difficulties now being experienced in silos, bins and bunkers could be greatly lessened if care were taken as to how the coal was spilled by the chutes.

5. Storing in Small Piles and Keeping the Storage Height as Low as Possible.—Six feet is considered high. This is applicable to small storage quantities.

6. Keeping Storage Away From Any External Sources of Heat.—Stored coal, for example, should not be close to hot steam pipes.

7. Avoiding Any Draft of Air Through the Coal.—It has been suggested in the past that a number of pipes be put through the coal to give ventilation. Attempts to ventilate generally cause more trouble than good. The best method is to prevent all access of air. It is usually not realized what a large amount of air passes through slits, cracks, ill-fitting gates, and coal-handling and storing equipment in general. If coal is piled on the ground, for example, the sides of the pile give opportunity for air movement; therefore coal placed level in a storage area having airtight sides and bottom would give less trouble from spontaneous heating. Only the top of

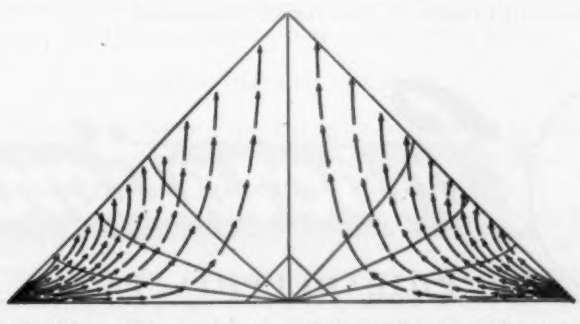

Fig. 5—Lines showing increasingly difficult paths for air circulation in a pile of coal

the coal could be reached by air. A layer of a few inches of very fine coal on the top would prevent effective air movement into the coal. It would be well for such a scheme to provide some type of covering to prevent the access of rain. The following is quoted from an article by M. K. Drewry in Combustion of February 1937:

"Sealing the sides and top of a coal storage pile to prevent or greatly reduce air circulation through it effectively inhibits spontaneous heating and permits long-time storage with small loss of heating value.

"Providing an airtight coating by a continuous layer of fine coal, approaching pulverized coal in fineness, is a practical and effective means of sealing a coal pile. A second covering of lump coal prevents wind and rain erosion of the fine coal layer.

"Winds are probably more responsible for air movement and heating in coal piles than is the stack effect within the pile.

"An airtight coating of asphalt actually extinguished combustion in a large pile and changed rapid heating into slow but positive cooling. A seal of fine coal caused the

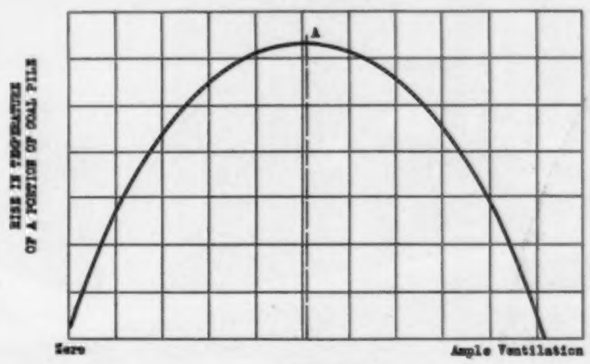

Fig. 6—Relation of heating to ventilation in a pile of coal

measured loss of another pile to be negligible. Fireproofing with fine coal has become an established practice where coal must be stored 9 months."

8. Using Older Portions of the Storage First, Avoiding Accumulations of Old Coal in Corners.—Such coal is apt to have the needed time for appreciable heating to develop. Dead coal space is a chronic trouble with much coal-storage equipment.

It is desirable to watch the temperature of the pile. This can be done by the use of thermometers. An iron rod driven into the coal will reveal temperatures; a pipe may be so used through which a thermometer may be dropped. When a temperature of about 120 F is reached in piles that have not been rolled, arrangements should be made to move the coal if the temperature continues to rise appreciably. In packed piles the temperature can be somewhat higher without much danger from actual firing. Spontaneous heating of coal is a relatively slow process; ordinary observation from time to time gives ample opportunity to prevent active firing. Using water to put out a fire may be effective for the moment, but in many instances such use only delays the necessity of moving the coal. Frequently coal stored when wet will give more trouble than when stored dry. The ventilation is affected. Small storage fires have been put out by smothering with carbon dioxide gas from "dry ice" or from the tanked liquid form.

Gamma-Ray Radiography of Welded High-Pressure Power Plant Piping

By R. W. EMERSON, Metallurgist,

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These excerpts from a paper before the A.S.T.M. at Atlantic City discuss the necessary apparatus, and the procedure used in the gamma-ray radiography of both circumferential and longitudinal seams in welded piping. Also discussed are the effect of size of radiant source, distance from source to film, metal thickness, and type of film on the resultant radiographic sensitivity.

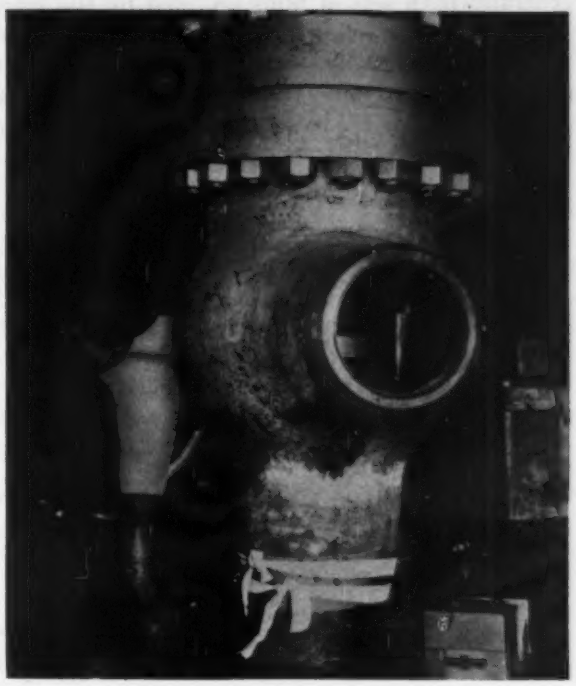


Fig. 1—Radiographing a 14-in., 1500-psi non-return valve on superheater header outlet

THE A.S.M.E. Power Boiler Code requires radiography of fusion-welded joints in (1) pipes or tubes and superheater headers exceeding 16 in. nominal pipe size or $1^5/_8$ in. in wall thickness that are to contain steam, and pipes or tubes exceeding 10 in. nominal pipe size or $1^1/_8$ in. in wall thickness that are to contain water when in each case the welds are not to be in contact with furnace gases; (2) in pipes or tubes exceeding 6 in. nominal pipe size or $^3/_4$ in. wall thickness when the welds are to be in contact with furnace gases but not subject to radiation from the furnace; and (3) in pipes or tubes exceeding 4 in. outside diameter or $^1/_2$ in. wall thickness when the welds are to be in contact with furnace gases and subject to radiation from the furnace.

In some cases, individuals have requested radiographic inspection of welded high-pressure piping which has not been within the scope of the Power Boiler Code. This is believed primarily to be due to the increased severity of service conditions placed upon power-plant piping.

Apparatus and Procedure

With the possible exception of a special jig or fixture for holding the radium capsule (gamma-ray source), the apparatus required is essentially as follows:

Lead numbers are placed on adhesive tape and in turn placed around the circumference or along the seam of the welded joint to be radiographed for the purpose of identifying the location of any possible defect registered on the film. Three sheets of 0.005-in. lead foil are alternated with two films and placed in a light-tight film holder. The film holder or holders (cassettes) are then strapped around the circumference or along the seam to be radiographed by means of 2-in. wide elastic banding. Penetrameters or sensitivity gages are placed adjacent to, but at the extremities of the portion of the joint undergoing exposure. These gages, whenever practicable, must be placed on the opposite side of the joint from the film. With the film in position, the radium capsule is placed in position at a suitable distance on the side of the joint opposite to that from the film.

Since radium continuously emanates gamma rays, exposure begins immediately upon placement of the radium into exposure position. The time of exposure is dependent upon the quantity of radium being used, the distance from radium to film, the thickness of the steel being radiographed, and the film speed. These factors being known, the time of exposure is calculated by use of an exposure meter.

There are at least four reasons for the use of the double-film technique as described.

1. By slightly underexposing the film for single viewing and then viewing the two films superimposed, an increase in contrast is believed to be obtained over that by a longer exposure using single film.
2. Simultaneously with increased contrast, which is highly desirable in gamma-ray radiography, a reduction in exposure time using double film is accomplished.
3. Any variation in film density resulting from defective film or improper developing can be readily checked, by checking one film against the other, it being relatively

certain that unless variation in film density is coincident when the two films are viewed superimposed, such variations would not be the result of defective material undergoing inspection.

4. The use of double film provides, if necessary, a record for both the fabricator and the customer, though generally both sets of films are filed by the fabricator.

The procedure followed in placing the radium and film will depend primarily on whether the pipe weld undergoing inspection is longitudinal or circumferential; in

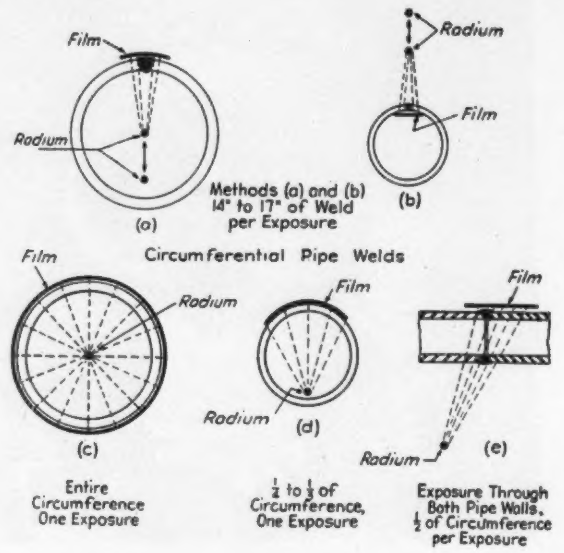


Fig. 2—Exposure methods for pipe welds

the case of either the placement will further depend upon both the pipe diameter and wall thickness. When making a radiographic set-up, the quality of the resulting radiograph must first be considered, and second, the time involved to obtain the desired results.

Several procedures used in setting up for radiography of both longitudinal and circumferential seams are shown in Fig. 2. In this (*a*) and (*b*) illustrate the methods used in radiographing longitudinal pipe seams. Method (*a*) is usually used when the nominal pipe diameter exceeds 10 in. and method (*b*) is used when diameter is less than 10 in. The length of seam normally radiographed at one exposure is one to one and one-half times the perpendicular distance from the radium to film, the factor of one being used when the pipe wall thickness is 2 in. or greater, and this factor increases to one and one-half for a wall thickness of 1 in. or less. For longitudinal welded seams in which the wall thickness does not exceed 1 in. and the radium capsule does not exceed 100 mg, the optimum length of seam to radiograph at one exposure would be 14 to 17 in., using a radium-to-film distance of 9 to 12 in., respectively. By doubling the radium-to-film distance, the length of seam radiographed at one exposure could likewise be doubled. By doing this, however, the exposure time is quadrupled, thus resulting in an ultimate net loss in time of approximately 50 per cent.

Three general methods of placing the radium and film are applicable to circumferential welds as shown in Fig. 2 (*c*), (*d*) and (*e*). Of these three, method (*c*), in which the radium is placed centrally within the pipe and the film wrapped around the entire circumference, is far superior to either of the other two schemes. Fortunately 90 to 95 per cent of the circumferential welds in piping can be radiographed using this method. This method can be used on all nominal pipe sizes down to and including 6 in. in diameter. Method (*d*) may be used on all pipe sizes down to and including 4 in. in diameter but has the disadvantage of requiring three or four separate exposures which, in addition to the added exposure time, require additional set-up time and therefore would not be used on any pipe size in which method (*c*) is adequate. Method (*e*) can be used for pipe sizes of 4 in. and smaller. When using this method, both the radium and the film are placed external with respect to the pipe and a radiograph of both the front and back wall of the pipe is taken with one exposure. Due to the relative thickening of the top and bottom quarter segments, these portions of the joint are underexposed.

After the first exposure, the pipe is then rotated 90 deg and a second exposure is made in order to get the upper and lower quadrants.

A Discussion and Experimental Study of Sensitivity

A gamma-ray radiograph is in reality a shadow picture produced by emanating gamma-rays which are absorbed to various degrees depending upon the thickness of the metal through which the rays must pass. Those rays not absorbed by the material undergoing inspection are picked up by the film, the density of which varies with the intensity of the rays reaching the film.

A simple analogy may be shown to exist between gamma-ray shadow pictures and ordinary light-ray

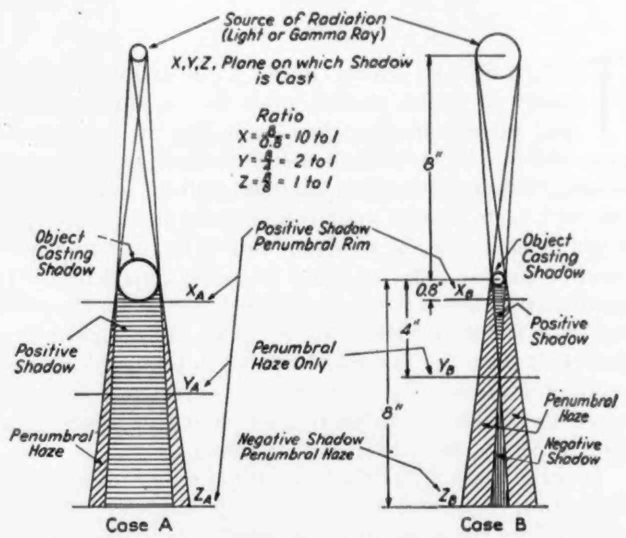


Fig. 3—Schematic diagram of shadow formation (Doan)

Case *A*—Source of radiation smaller than object casting shadow.
Case *B*—Source of radiation larger than object casting shadow.

shadow pictures. Two general cases exist, in the discussion of either of the two types of shadow pictures, as follows:

A. The source of radiation is smaller than the object casting the shadow.

B. The source of radiation is larger than the object casting the shadow.

It may be seen from Fig. 3 that case *A* is relatively simple; a positive shadow will always be formed and will

have only a relatively narrow fringe of penumbral haze.

Case B, however, is decidedly more complex; a positive shadow accompanied by a narrow band of haze can only be obtained by having a relatively large ratio of the distance from radiant source to object casting the shadow to the distance from object casting the shadow to plane where shadow is cast.

As this ratio is decreased the positive shadow decreases and the band of penumbral haze increases until a plane is reached at which the positive shadow completely disappears and only penumbral haze exists. Further reduction in the ratio results in the formation of negative shadow and penumbral haze only. The most desirable shadow picture is logically one in which high contrast and good definition can be obtained.

The simplest and most logical method of radiographing circumferential pipe welds, as previously mentioned, is that of placing the radium on the circumferential center line as shown in Fig. 2 (c). It is to be noted that the source-to-film ratio, when using this method, becomes automatically fixed. Since it is desirable to locate the smallest possible defects and since a positive shadow accompanied by a minimum of penumbra is further desirable, it becomes clear that the size of the source of radiation must be reasonably near if not equal in size to the smallest defect which is expected to be found, unless, of course, a reasonably large source-to-film ratio can be maintained. If this ratio is small, however, and the flaw diameter (taken perpendicular to the path of the rays) is small with respect to the radiant source, the true shadow will then be convergent and may be entirely lost to the film. The negative and penumbral shadows are, however, divergent and while Doan has shown penumbral shadow registry of flaws, this is not believed to be too reliable for flaw depths as small as $^1/_{32}$ in. with flaw diameters of approximately the same magnitude since the variation in density between the penumbral shadow of such a small defect and the adjacent film would be very small. Furthermore, defects producing a given low contrast become increasingly hard to locate as the size of the defects decreases.

In discussing the size of defects observable (sensitivity), the question might be asked, "What is sensitivity and how is it defined?" In the opinion of the author, sensitivity is the degree to which the process is capable of detecting flaws. It is further the author's opinion that 2 per cent sensitivity, which is the established requirement of the A.S.M.E. Power Boiler Code, does or should mean that the process must be capable of detecting a defect which has a depth, parallel to the path of the rays, of 2 per cent of the plate thickness and a diameter of equal size measured perpendicular to the path of the rays. Whether such defects have been picked up, if present, is determined by the observation of a sensitivity gage or penetrameter which is placed on the steel being radiographed. The latest type of penetrameter is a single thickness strip of mild steel $^1/_2$ by $1^1/_2$ in. which must have a thickness of 2 per cent of the plate thickness. This strip contains three holes having diameters of 2, 3 and 4 times the strip (penetrameter) thickness. The A.S.M.E. Code states that the image of all three holes shall be visible. This means that it should be possible to detect a defect having a depth of 2 per cent of the plate thickness and a diameter of 4 per cent of the plate thickness (smallest hole in penetrameter).

TABLE I.—ABSOLUTE RADIOGRAPHIC SENSITIVITY AS EFFECTED BY SOURCE-TO-FILM DISTANCE METAL THICKNESS, AND SOURCE INTENSITY.

Exposure	Radium Capsule, mg.	Distance, in. (A) Source to Plane of Holes	Distance, in. (B) Plane of Holes to Film	Ratio $\frac{A}{B}$	Depth of Last Hole Visible, in. $^1/_{16}$-in. Hole	Depth of Last Hole Visible, in. $^1/_8$-in. Hole	Depth of Last Hole Visible, in. $^3/_{16}$-in. Hole	Comments
No. 1		1.75	0.50	3.50	0.01	0.01	0.01?	Hazy—0.01 very faint
No. 2		3.50	0.50	7.00	0.01	0.01	0.01	Better detail than No. 1—0.01 very faint
No. 3		3.50	1.00	3.50	0.02?	0.02?	0.02?	Hazy—enlargement of image of holes
No. 4		5.25	0.50	10.50	0.01?	0.01	0.01	Sharp image—0.01 very faint
No. 5	25	5.25	1.00	5.25	0.02	0.02	0.02	Sharp image—slight enlargement
No. 6		5.25	1.50	3.50	0.03	0.03	0.03	Very hazy—enlargement of image
No. 7		7.00	0.50	14.00	0.01?	0.01	0.01	Extremely sharp image—0.01 faint
No. 8		7.00	1.00	7.00	0.03	0.02	0.02	Sharp image
No. 9		7.00	1.50	4.67	....	....	....	Underexposed
No. 11		1.75	0.50	3.50	0.02	0.02	0.02	Much more hazy than No. 1
No. 21		3.50	0.50	7.00	0.02	0.02	0.02	Hazy but improved over No. 11
No. 31		3.50	1.00	3.50	0.03	0.03	0.03	Very indistinct and hazy
No. 41		5.25	0.50	10.50	0.02	0.01	0.01	Sharp image—good detail
No. 51		5.25	1.00	5.25	0.03	0.02	0.02	Hazy image—0.02 faint
No. 61	100	5.25	1.50	3.50	0.03?	0.03	0.03	Very hazy and enlarged image poor—0.03 faint.
No. 71		7.00	0.50	14.00	0.01?	0.01	0.01	Sharp image—good—0.01 faint
No. 81		7.00	1.00	7.00	0.03	0.02	0.02	Hazy but fair detail—0.02 faint
No. 91		7.00	1.50	4.67	0.03	0.03	0.03	Fair detail—0.03 faint

Since the penetrameter itself is large with respect to the gamma-ray source, a positive shadow is cast on the film and, according to Fig. 3, case A, the penetrameter image will be seen. The holes in the penetrameter are sufficiently small with respect to the source in some cases so that the positive shadows cast by these holes converge to a point and therefore cast only a hazy penumbral shadow, if a shadow is cast at all.

It is for this reason that the outline of the penetrameter can be readily detected when at times the small penetrameter holes are difficult to pick up. If the outline of the penetrameter can be picked up on the film but the penetrameter holes are not visible, this indicates that the source-to-film ratio is too small or the size of the source is too large or perhaps both.

Radiographic sensitivity as indicated by the penetrameter image is to a very large extent dependent upon the type of film used. When using a fast coarse-grain film having a 20 per cent slide-rule factor the limiting absolute sensitivity has been found to be about 0.02 in. This limiting sensitivity was found to hold true for source-

to-film ratios as high as 25 to 1 with wall thickness as low as $^3/_8$ in. This results in a relative sensitivity of 2 per cent or better for respective wall thickness of 1 in. or slightly greater, with a rapidly diminishing sensitivity of as low as 5.3 per cent for $^3/_8$-in. thick material.

The use of a more recently developed fine-grain film having a 150 per cent slide-rule factor has been found to pick up readily four of the five steps of the type of penetrameter first described. With this film, the limiting absolute sensitivity has been found to be about 0.01 in. This has been found to hold true, as in the above case, for ratios as high as 25 to 1 and wall thickness as low as $^5/_{16}$ in. With a limiting absolute sensitivity of 0.01 in. it is therefore possible with this type of film to obtain a relative sensitivity of 2 per cent on material thickness as low as $^1/_2$ in. as contrasted with 1-in. thickness using the higher speed film.

The source intensity is related to the size of the source; the greater the intensity, the larger the source. It therefore becomes obvious, in view of previous discussion, that in order to obtain equal results, it is necessary to use increasingly larger source-to-film ratios with increasingly larger source intensities. The results shown in Table I are believed to illustrate this fact.

This table gives the results of a study in which a $^1/_2$-in. thick machined-steel block was drilled with three series of holes having diameters of $^1/_{16}$, $^1/_8$ and $^3/_{16}$ in. and depths ranging from 0.010 to 0.100 in. in steps of 0.010 in. Two additional $^1/_2$-in. blocks were machined and used to build up the steel thickness to $1^1/_2$ in. Various source-to-film ratios were used as indicated in the table and the depth of the shallowest hole visible is listed. A 25-mg radium source was used in exposures Nos. 1 to 9 and a 100-mg source was used in exposures Nos. 11 to 91. A high-contrast fine-grain film having a 150 per cent slide-rule factor was used in all exposures.

In contrasting exposures Nos. 1, 2 and 3 with respective exposures Nos. 11, 12 and 13, it can be seen that the results of the former three, in which the 25-mg source was used, are definitely superior to the latter. As the source-to-film ratio is increased, however, it may be seen that superiority of the smaller capsule diminishes, though it may be said that for exposures in which the source-to-film ratio is less than 7 to 1, a 50-mg source should not be exceeded, with a 25-mg capsule preferable.

Summary

Gamma-ray radiography is believed preferable to X-ray radiography for use in radiographing circumferential pipe welds, due to the relative simplicity and greater adaptability of the former method. This is particularly true where field radiography is required.

When radiographing circumferential pipe welds in which the radium is placed centrally, the source-to-film ratio seldom exceeds 7 to 1 and may be as low as 3 to 1. When working with such low ratios, the size of the radium source should never exceed 50 mg and should preferably be 25 mg, if good radiographic detail is to be expected under these conditions.

Under the most favorable radiographic conditions, the absolute sensitivity of the higher-speed coarse-grain films, such as Eastman Type K and Agfa Non-Screen, was found to be 0.02 in. The use of a slower-speed fine-grain film, such as Eastman Type A, however, was found to have an absolute sensitivity of 0.01 in. or better. The type of film to be used will, of course, depend upon, first the results desired and, second, the exposure time required.

From the results of test welds, as well as welds made in production, it is felt that the gamma-ray method of radiography will adequately pick up both major and minor weld defects.

The author is grateful for the cooperation given by G. Sinding-Larsen, Chief Engineer, and G. W. Petrie, Jr., Plant Superintendent, Pittsburgh Piping and Equipment Co., and also wishes to acknowledge the laboratory assistance given by Mathew Morrow.

REFERENCES

R. F. Mehl, G. E. Doan and C. S. Barrett, "Radiography by the Use of Gamma Rays," *Transactions*, Am. Soc. Steel Treating, Vol. 18, p. 1192 (1930).

R. A. Gezelius and C. W. Briggs, "Radium for Industrial Radiography."

G. E. Doan and Shang-Shoa Young, "Gamma-Ray Radiography," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 292 (1938).

J. T. Norton and A. Ziegler, "Sensitivity of the Gamma-Ray Method of Radiography," *Transactions*, Am. Soc. Steel Treating, Vol. 22, No. 3, p. 271 (1934).

Norman L. Mochel, "Gamma-ray Radiography and Its Relation to X-ray Radiography," Symposium on Radiography and X-ray Diffraction Methods, Am. Soc. Testing Mats. (1936). (Symposium issued as separate publication.)

Progress in Coal Storage

Under the war drive to build up consumers' stockpiles of coal, as insurance against a possible later shortage due to transportation demands, $5^1/_2$ million tons were added during the month of May. This brought up to 67,409,000 tons, the estimated amount of soft coal held by consumers on June 1, which represented 49 days' supply for the Nation as a whole, based on the May rate of consumption. In other words, it was an increase of six days' supply over the average of 43 days held on May 1.

During May the total coal consumption reflected a decrease of 1.7 per cent. While certain classes of users showed an increase, this was more than offset by some groups of manufacturing industries which dropped as much as 9.2 per cent and by the steel and rolling mills which dropped 5.1 per cent during the month.

Obviously, there was wide difference among the industries as to the number of days' supply in storage. For example, the electric utilities, which have always been farsighted in this respect, reported 96 days' supply as of June 1, whereas that for steel mills was 42 days and for railroads 35 days.

Despite the considerable amount of coal that went into storage during May, Howard A. Gray, Acting Director of the Office of Solid Fuels Coordinator, has cautioned that this is not sufficient as an insurance against possible interrupted supply next fall and winter when the heaviest loads will fall on the railroad facilities. Estimates prepared by his office indicate that adequate protection would require 60 to 90 days' supply for non-war industrials and 90 to 120 days' supply for public utilities and industrials engaged in war production. Householders should store their entire next winter's supply during the summer.

Boilers of Latest C-2 Ships

A TWIN ceremony marked the launching of two C-2 cargo ships, the "Santa Cecilia" and the "Santa Margarita," at the Kearny, N. J., yard of the Federal Shipbuilding and Dry Dock Company on June 28. These ships, designed before Pearl Harbor for the South American trade, were built by the U. S. Maritime Commission for transfer to the Grace Line upon completion. One was christened by Mrs. J. P. Grace, Jr., daughter-in-law of Joseph P. Grace, Chairman of the Board of W. R. Grace & Co., and the other by Mrs. R. R. Adams, wife of the executive vice president of the Grace Line.

Unlike the Liberty Ships whose power plants, consisting of 220-lb sectional-header boilers and reciprocating engines, were described in the May issue of COMBUSTION, these vessels each have two CE bent-tube boilers supplying steam at 465 lb, 765 F to a 6000-hp geared steam turbine. These are the first of sixteen vessels to be thus equipped, although a considerable number of C-2 ships are already in service.

The boilers are of the double V2M type, set side by side with a common partition wall between, as will be noted by reference to Figs. 1 and 2. The furnaces are completely water cooled. Each unit has approximately 3075 sq ft of heating surface, including 405 sq ft of water wall surface, and a nominal rating of 26,500 lb (40,000 lb maximum) of steam per hour. A horizontal Elesco superheater, shaded by three rows of boiler tubes, a de-

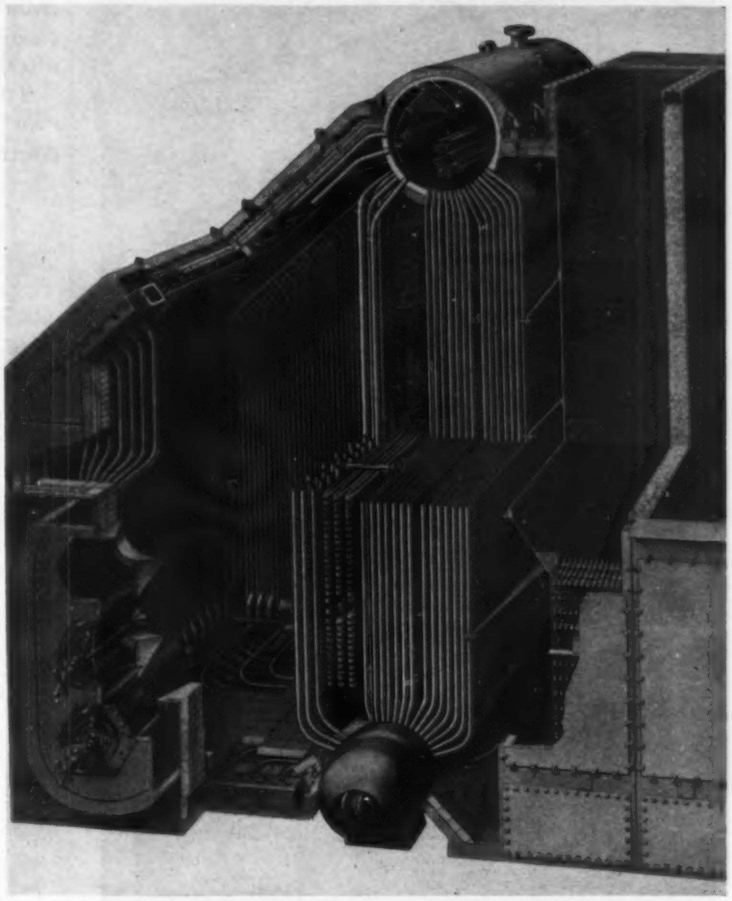
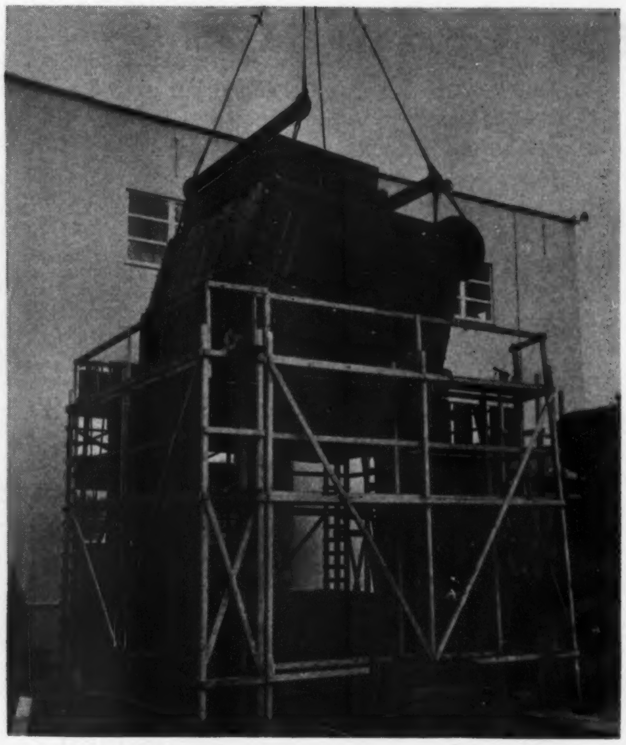
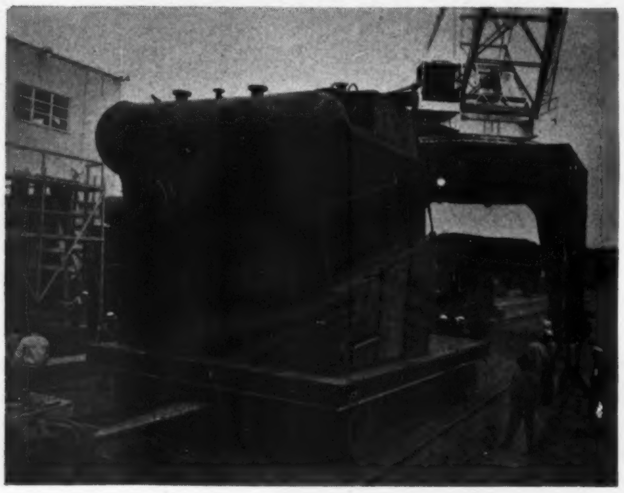


Fig. 1—Section through of the double-set boilers

Fig. 2—Casing for two units assembled on shop floor





Boiler handling at a West Coast Shipyard

Boilers for Liberty Ships are completely assembled within the scaffold (upper view), pickedup by a traveling crane and transported to the ship on a trailer (middle view), and then lowered into the ship by a second crane.

superheater in the upper drum and a fin-tube economizer in series with a CE tubular air heater form integral parts of each unit. The whole is enclosed in an insulated steel casing containing the hot air ducts from the air heaters to the burner wind boxes. This casing is compact, yet provides accessibility to the interior parts.

Three Todd oil burners fire each furnace and Vulcan soot blowers are provided. The automatic combustion control is of the Mason-Neilan type.

GUESTS AT LAUNCHING

Among those attending the dual launching were Joseph P. Grace, chairman of the board of W. R. Grace & Co. and Grace Line; Miss Maureen Grace, Charles Grace, Michael Grace, D. Stewart Iglehart, president of W. R. Grace & Co., and Grace Line; Mr. and Mrs. George Doubleday, Adolph Garni, first vice president of W. R. Grace & Co., and Mrs. Garni, Harold J. Roig, president of Pan-American-Grace Airways, and Mrs. Roig; W. R. Holloway, vice president, W. R. Grace & Co., and Mrs. Holloway; John T. Kirby, vice president of W. R. Grace & Co., and Mrs. Kirby; J. E. Zalles, vice president of W. R. Grace & Co., and Mrs. Zalles.

Also R. H. Patchin, vice president of W. R. Grace & Co., and Mrs. Patchin; Andrew B. Shea, vice president of W. R. Grace & Co., and Mrs. Shea; William F. Cogswell, vice president of W. R. Grace & Co., and Mrs. Cogswell; Chester R. Dewey, president of Grace National Bank, and Mrs. Dewey; Miss Margaret Adams, John W. Chapman, vice president of the Grace Line, and Mrs. Chapman; John C. Kelly, president of Kelly, Nason, Inc., and Mrs. Kelly; James R. P. Nason, executive vice president and treasurer of Kelly, Nason, Inc., and Mrs. Nason, and James E. Magner, vice president of the Grace Line, now connected with the War Shipping Administration, and Mrs. Magner.

Representatives of Combustion Engineering Company, Inc., included J. V. Santry, president, and Messrs. Ferris, Kruse, Maak, Hockstrasser and Worsfold.

To Broadcast Program on "The Engineer at War"

Dr. R. L. Sackett, on behalf of the national engineering societies, has announced that beginning Thursday, July 16, the National Broadcasting Company will broadcast a series of eleven programs dealing with the contribution of engineers to the prosecution of the war. The broadcasts will be from 6:30 to 6:45 p.m. each Thursday through September 24 over the national network and possibly by short wave.

In 1941 The American Institute of Electrical Engineers broadcasted a series of similar programs. They were so successful that The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Mechanical Engineers, The American Institute of Electrical Engineers and The American Institute of Chemical Engineers appointed three representatives of each society to form a committee to discuss possible programs dealing with subjects that are particularly pertinent to defense.

This committee, which began its deliberations before Pearl Harbor was attacked, has been generously helped by the Office of Civilian Defense and the National Broadcasting Company of which Dr. James Rowland Angell is Public Service Counsellor.

The programs will cover blackouts, protection against incendiary bombs and gas, resistance of structures, the Navy and ships and other pertinent topics. On September 10, Glen B. Warren, of the General Electric Company, will discuss "Steam and Hydro Power."

Fuel Engineering Conference

The Coal Bureau of the Upper Monongahela Valley Association, in cooperation with the School of Mines of West Virginia University has arranged a Fuel Engineering Conference to be held on July 24 at that university in Morgantown, W. Va.

The purpose in arranging this conference is to bring together industrial consumers, equipment manufacturers, fuel and research engineers, to discuss problems incident to the fuel situation in the Eastern Region resulting from the war.

Following opening remarks by the Director, J. E. Tobey, and an address of welcome by Dr. C. E. Lowall, President of the University, a program of four papers will be presented at the morning session. These include the "History and Economics of the Pittsburgh Coal Bed in West Virginia," by H. N. Eavenson, and its "Geology" by Dr. P. H. Price. "The Future of Northern West Virginia Coals" will be discussed by E. G. Bailey; and E. C. Payne of Consolidation Coal Co. will deal with "Meeting War Time Fuel Demands in Industrial Plants."

Two papers and a Panel Discussion on research will fill the afternoon program. Theodore Maynz will deal with "Latitude in Coal Selection Through Plant Modernization" and G. B. Gould will present a paper on "War and the National Fuels Situation." Leaders in the Panel Discussion will be R. A. Sherman of Battelle Memorial Institute and H. N. Eavenson, President of Bituminous Coal Research, Inc.

Electric Production and Capacity

Electric energy produced for public use in May 1942 totaled 14,745,615,000 kwhr, which represented an increase of 10.2 per cent over that for May 1941, according to the latest figures issued by the Federal Power Commission.

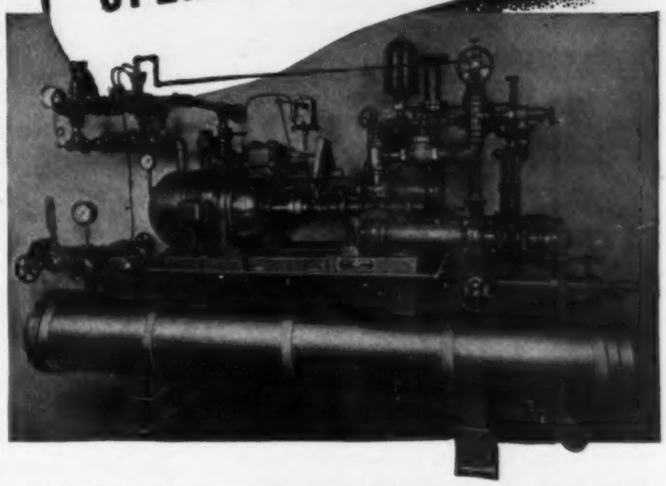
The average daily production was 1.1 per cent greater than during April and water power accounted for 36.2 per cent of the total output. Furthermore, for the twelve months ending May 31, 1942, the total production of electricity exceeded that of the preceding twelve-month period by 15.6 per cent.

The capacity of generating plants supplying power for public use in the United States, as of May 31 last, is given as 45,189,184 kw, or a net increase of 143,493 kw for that month.

De Laval Awarded Navy "E"

For outstanding achievement in the production of turbines, gears, pumps and other equipment vital to the United States Navy, the Navy "E" burgee, symbol of "Work Well Done," was presented to the De Laval Steam Turbine Company, Trenton, N. J., June 29, 1942, at which time also the employees received the "E" lapel insignia. The presentation speech was made by Rear Admiral William C. Watts, U.S.N., Ret., and was responded to by H. L. Watson, Executive Vice President of the De Laval Company.

To date over eleven million horsepower of De Laval marine turbines and speed reducing gears have been delivered, or are under construction, for the propulsion of destroyers, cruisers and merchant vessels, as well as large numbers of centrifugal pumps for marine service.



REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Proceedings of the Midwest Power Conference—April 1942

The Illinois Institute of Technology, chief sponsor of the Midwest Power Conference, has published a report of the proceedings at the meeting held in Chicago, April 9 and 10, 1942. The report comprises addresses and technical papers given before the conference, and contributed by the representatives of the cooperating educational institutions, engineering societies, industries and utilities. Subjects discussed at the different sessions included—Central Station Practice; Electric Power Transmission; Industrial Power Plants; Hydro Power; Boilers and Stokers; and Diesel Power.

The report is illustrated and comprises 216 pages, size 6×9, with paper covers. Price $2.00.

Recommended Practices for Inspection of Fusion Welding

The American Welding Society has recently published a committee report under the above title. This report represents a comprehensive treatment of the many factors involved in the inspection of welds made by the arc and oxyacetylene processes. The subjects covered include: qualifications of welding inspectors; duties of inspectors; inspection and testing of welded structures; inspection during construction; shop and field inspections; examination of welds; radiographic inspection, hydrostatic testing and magnetic powder inspection. A considerable part of the report deals with the welding characteristics of both ferrous and nonferrous metals. This report is in the form of a 23-page bulletin with a heavy paper cover, available at 40¢ per single copy.

Second Report on Refractory Materials

Considerable work has been done by the Iron and Steel Research Council and the British Refractories Research Association since their first report was issued in March 1939. Much of this work concerning various types of refractories used in the iron and steel industry and a summary of other recent investigations is now contained in this Second Report.

In the section devoted to Steelworks Refractories, the work of the Open-Hearth Refractories Joint Panel, 1939–1942, is reviewed. A study of the reactions between dolomite and various minerals is also given, which includes X-ray examinations of the dolomite B and of the sinters containing Zirconia. In the section dealing with Blast-Furnace Refractories the influence of working conditions on the durability of blast-furnace linings is dealt with, and also temperature gradients through blast-furnace linings. A summary of other published work of the B.R.R.A. of interest to the iron and steel industry is also given. Many illustrations and charts accompany the text.

The book comprises 168 pages, size $5^3/_8 \times 8^3/_8$, and is bound in stiff cardboard. Price 16*s*.

Trade and Professional Associations of the United States

This volume, compiled by the U. S. Department of Commerce under the direction of C. J. Judkins, Chief of the Trade Associations Section, presents basic data on such national groups as trade organizations, professional, consumer and farmer organizations, patriotic societies, and labor unions. All associations are classified into industrial and geographical groupings, and summarized census data are given on the relative size of all major industries in the United States. The principal activities of each organization, size of staff and number of members are given and other factual matter such as the number of factories, retail stores, farms and service establishments is included for each of the 48 states.

The publication reveals that there are now 1100 important associations of manufacturers, 400 of wholesalers and retailers and 560 of transportation, finance and other service organizations, many of which have been of great assistance to the Federal Government in such matters as speeding up production of war materials, perfecting standardization economies, and aiding in technical research for substitute products and in factory conversion to war needs.

This 320-page book, size $9^1/_4 \times 11^3/_8$, may be procured from the Government Printing Office, Washington, D. C. Price 70 cents.

Water Handbook

This handbook, published by W. H. and L. D. Betz, is arranged in two sections, "Water Analyses" and "Interpretations." In Part 1, twenty-five different methods of water analyses are discussed at length, with procedures and calculations. Such water analyses as Hardness, Alkalinity, Phosphate, Sulfite, Turbidity, Oil, Calcium, Specific Conductance, etc., are covered, but bacteriological analyses are not included. Part 2 of the book is devoted to interpretations of the tests and their application to plant control. Included are discussions of such subjects as Carbonate and Non-carbonate Hardness, pH Control, Steam Purity, Inter-crystalline Cracking, Corrosion, etc.

This 64-page handbook is illustrated with sixteen useful charts and fifteen photographic halftones of different pieces of testing equipment. The book is spiral bound, size $8^1/_2 \times 11$. Price 50 cents postpaid.

A midwest utility company has protected this transformer station with a wall of Celocrete blocks (expanded blast furnace slag) filled with sand. The wall affords complete protection against high-powered rifle and machine gun fire.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Care of Motors

With motors operating 168 hours a week instead of 40 hours as formerly, most books on motor care are now seriously out of date. To correct this situation, Allis-Chalmers has just published a new handbook entitled "A Guide to Wartime Care of Electric Motors." Taking a fresh, new slant at the subject of motor care under war conditions, the book is of great value to war plant engineers and maintenance men, and is of particular value for training new men. The book contains no advertising, and is available upon request.

Gas and Oil Burner

A new bulletin, No. 702, describing the Peabody combined gas and oil burner for petroleum refinery furnaces has just been issued by the Peabody Engineering Corporation. A quickly removable gas burner ring and general air register and oil atomizer improvements are described.

Maintenance Hints

Westinghouse Electric and Manufacturing Company has issued a two-volume set of maintenance rules and suggestions which is now available to maintenance men concerned with the care of electrical apparatus in industry. The books comprise 15 chapters written by Westinghouse engineers, total 220 pages, and are made up for loose-leaf insertion in 4 × 7 binders.

Volume One covers inspection of electrical apparatus, insulation materials and applications, the cleaning, drying and testing of insulation, commutator maintenance, starting and regulating a-c, d-c and squirrel cage induction motors. Diagrams, tables and charts make the text easy to follow. Volume Two is devoted to contactor maintenance, the inspection of transformers and a chapter on transformer connections. Wiring diagrams embrace all of the more common connections for two and three phase, 25- and 60-cycle power transmission.

Pump Data Sheets

As a special war-time service to pump operators, Goulds Pumps, Inc., has made available the company's "Pump Application Sheets." These sheets, of two to eight pages each, include both elementary and advanced technical data on selection, installation, operation and maintenance of all types of industrial pumps for general and specialized services.

The sheets, together with an 18-page booklet, "Pump Fundamentals," are furnished in a durable folder without charge. From six to fourteen sheets will be placed in each folder, depending upon the type of information deemed most useful to the recipient. Address requests to Department 18, Goulds Pumps, Inc., Seneca Falls, N. Y.

Temperature and Pressure Controllers

A 36-page catalog (No. 900E) has been issued by the C. J. Tagliabue Manufacturing Company which lists its line of standard automatic non-indicating controllers. Instruments described include temperature controllers, pressure controllers, time controllers, thermostatic steam traps, temperature-time and pressure-time controllers, temperature-condensation-time controllers and multi-cam cycle controllers or timers. This lavishly illustrated booklet also describes Tag diaphragm valves, compressed air equipment, steam operator controllers and miscellaneous instrument parts and fittings.

Sound Determination for Fans and Blowers

In order to provide a standard method of measuring sound in fans and blowers the National Association of Fan Manufacturers has issued a new 8-page bulletin (No. 104) entitled "Sound Measurement Test Code for Centrifugal and Axial Fans," covering fans for air conditioning, heating, ventilating and general air handling problems. Incorporated in the code are standards previously adopted or tentatively accepted by the American Standards Association and the U. S. Navy.

EQUIPMENT SALES

as reported by equipment manufacturers to the Department of Commerce, Bureau of the Census

Boiler Sales

Stationary Power Boilers

	1942 Water Tube		1941 Water Tube		1942 HRT Type		1941 HRT Type	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan........	202	1,637,588	170	968,275	53	61,990	89	123,459
Feb........	238	1,557,004	97	847,331	59	84,660	81	104,622
Mar........	‡273	1,520,654	‡138	988,037	166	92,999	86	89,324
Apr........	430	2,441,668	159	802,993	57	81,402	129	151,636
May........	163	1,304,236	134	850,659	63	90,079	114	154,964
Jan. - May Incl.....	1,306	8,461,150	698	4,457,295	398	411,130	499	624,005

* Includes water wall heating surface. ‡ Revised.

Total steam generating capacity of water tube boilers sold in the period January to May (incl.) 1942, 69,953,000 lb per hr; in 1941, 46,335,000 lb per hr.

† Mechanical Stoker Sales

	1942 Water Tube		1941 Water Tube		1942 Fire Tube		1941 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan......	87	42,876	77	41,975	159	24,135	94	14,036
Feb......	131	55,001	60	27,736	185	26,889	117	14,774
Mar......	84	46,005	69	31,342	212	33,395	146	21,552
Apr......	103	49,441	75	34,832	313	39,877	147	20,555
May......	125	44,069	90	43,971	206	33,566	144	19,267
Jan. - May Incl....	530	237,392	371	179,856	1,075	157,862	648	90,184

† Capacity over 300 lb of coal per hr.

Pulverizer Sales

	1942 Water Tube No.			1941 Water Tube No.			1942 Fire Tube No.			1941 Fire Tube No.		
	(N)	(E)	Coal Lb/hr	(N)	(E)	Coal Lb/hr	(N)	(E)	Coal Lb/hr	(N)	(E)	Coal Lb/hr
Jan.......	102	3	1,071,340	39	—	462,990	—	—	—	—	1	1,000
Feb.......	21	1	246,520	42	4	734,200	—	—	—	—	—	—
Mar.......	31	7	360,620	31	3	739,700	1	—	13,300	—	—	—
Apr	49	8	845,740	14	8	225,740	—	—	—	1	—	2,800
May......	28	4	415,780	54	10	777,320	—	—	—	—	4	7,000
Jan.-May Incl....	231	23	2,940,000	180	25	2,939,950	1	—	13,300	1	5	10,800

(N)—New Boilers; (E)—Existing Boilers.

New Welding Standards

The American Welding Society has recently published two welding standards, entitled "Standard Methods for Mechanical Testing of Welds" and "Definitions of Welding Terms and Master Chart of Welding Processes." Both of these standards were prepared by technical committees of the Society and are revisions of earlier bulletins of the same title. The former describes in detail the principal mechanical tests applied to welds, including tests for density, soundness, tensile strength, shearing strength and ductility (bend tests). The booklet includes sketches of the specimens and descriptions of the methods of testing and evaluating the results. Some of the tests apply to the weld metal alone; others apply to butt-welded joints and fillet-welded joints. In addition there is a section on etching reagents and procedures for etching.

The "Definitions of Welding Terms and Master Chart of Welding Processes" gives the standard definitions of welding terms adopted by the American Welding Society. The terms are grouped under appropriate headings and subheadings so that closely related terms appear together and their relationships may be more readily understood. In addition the booklet includes an index in which all terms are listed alphabetically. Fifty-one illustrations assist in making the various definitions clear. The booklet also includes a chart showing the various subdivisions of the principal welding processes, namely: forge welding, resistance welding, arc welding, gas welding, thermit welding and brazing.

Airplane Engines Generate Power for Shops

New airplane engines which once consumed great quantities of aviation gasoline but did no useful work during breaking-in runs now have been harnessed to produce power for machine tools and lights, according to R. H. Wright, engineer at the Westinghouse Electric and Manufacturing Company.

This has been achieved by harnessing the airplane engines to ordinary generators of the type long used in small diesel-electric power plants. One large airplane engine manufacturer has already been supplied with sixteen of these generators.

By installing generators in test cells, each aircraft engine can produce about 2000 kwhr during its test runs. Generators now in use in one factory will produce each month more than 4,000,000 kwhr, worth about $24,000. This much electricity is enough to supply the entire factory—driving lathes, drills, grinders, boring machines and other machinery used to manufacture airplane engines, as well as factory lights.

The generators can also operate as motors to crank the stiff, new engines for their first trial run. Then, after the engines gain speed under their own power, the electrical machines automatically become generators, producing power instead of using it. By measuring the amount of electricity generated, engineers can tell whether the engine is running properly. Such accurate checks are not possible when the engines drive propellers in test cells not equipped with generators.

Personals

A. C. Weigel, Vice President of Combustion Engineering Company, was elected Vice President of the American Boiler Manufacturers Association and Affiliated Industries at its Annual Meeting, held at Skytop, Pa., early in June.

L. A. Kunzler has been made Field Manager of the Tube Cleaner Department of Elliott Company at Springfield, O. Mr. Kunzler has been with the Company since 1935 and for the last four years has been attached to the Tulsa Office.

J. P. Morrison, Assistant Chief Engineer of the Hartford Steam Boiler Inspection & Insurance Company is serving in the Bureau of Industrial Conservation of the War Production Board at Washington.

Howard N. Eavenson has been re-elected President of Bituminous Coal Research, Inc., the research agency of the bituminous coal industry.

Harold S. Osborne, Plant Engineer, American Telephone & Telegraph Company, was elected President of the American Institute of Electrical Engineers, as announced on June 22 at the Chicago Meeting of the Institute. His term will begin August 1, 1942.

John F. Randall, Metallurgist with Combustion Engineering Company, Inc., has recently joined the Service as a first lieutenant of artillery.

A. G. M. Michell, well known Australian engineer was recently awarded the James Watt International Medal by The Institution of Mechanical Engineers (Great Britain), in recognition of his outstanding work with thrust and journal bearings, as well as his contributions to engineering in connection with centrifugal pumps and crankless engines.

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